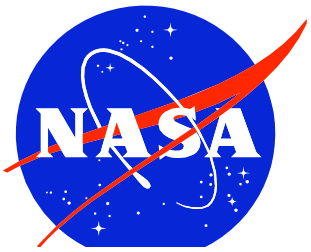
GSSC-000X

GAMMA-RAY LARGE AREA SPACE TELESCOPE (GLAST)

SCIENCE TOOLS DATABASES REQUIREMENTS

November 17, 2003



GODDARD SPACE FLIGHT CENTER
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(GLAST)

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NASA Goddard Space Flight Center

Greenbelt, Maryland

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1 Purpose

This document describes the requirements for databases (excluding LAT events) to be used with the science analysis tools for the GLAST mission. These databases have been identified by the GLAST SSC-LAT Working Group (SLWG). The analysis software will query the databases through specially devised access utilities. These databases will be populated by data generated from the LAT IOC.

2 Acronyms

API	Application Program Interface
DBMS	Database Management System
GBM	GLAST Burst Monitor
GIOC	GBM IOC
GRB	Gamma-Ray Burst
GSFC	Goddard Space Flight Center
GLAST	Gamma-ray Large Area Space Telescope
GSSC	GLAST Science Support Center
HEASARC	High Energy Astrophysics Science Archive Research Center
IOC	Instrument Operations Center
LAT	Large Area Telescope
LHEA	Laboratory for High Energy Astrophysics
LIOC	LAT IOC
NASA	National Aeronautics and Space Administration
SAA	South Atlantic Anomaly
SSC	Science Support Center
SLWG	SSC LAT Working Group
SWG	Science Working Group
TBD	To Be Determined
TBR	To Be Reviewed

3 Glossary

3.1 Level 1 Data

Level 1 data result from automated pipeline processing of Level 0 data. This processing applies the instrument calibration to remove instrument artifacts and convert the instrument measurements to physical units. If appropriate, Level 1 processing also converts celestial coordinates to J2000, the mission's standard representation. Level 1 data are generally the starting point for scientific analyses.

In LAT Level 1 processing, the Level 0 data, describing the interactions within the LAT, will be analyzed to identify and characterize the interacting particle (e.g., photons, electrons, protons, etc.). Thus tracks will be fitted to the hits in the tracker and calorimeter, the particle trajectories and energies will be estimated, and the event will be classified. The Level 1 data for an event will include not only the parameters from the analysis of the tracks, but also the time, the spacecraft ephemerides, etc. Other LAT Level 1 data will include histories of the instrument live time and exposure, as well as instrument response functions relevant to the observation.

3.2 Database Identifiers

The LAT Standard Analysis Environment document assigns all science tools, including databases, an identifier. Database identifiers consist of two characters, a "D" followed by a number. The following table lists the databases in the LAT SAE requirements document.

ID	Name	Description
D1ph	Photon data	List of all events that can be considered photons. Includes data necessary to calculate IRFs.
D1ev	Event data	Full characterization of the events for higher-level processing
D2	Pointing/livetime history	LAT orientation and mode at TBD-second intervals; used to calculate exposure
D3	LAT IRFs	Data necessary to calculate IRFs. Stored in CALDB.
D4	Pulsar ephemeris	Ephemerides of pulsars that might be detectable by GLAST
D5	LAT Point Source Catalog	Table of detected gamma-ray sources with derived information
D7	Interstellar emission model	Model for diffuse gamma-ray emission from the Milky Way, input for high-level data analysis; will be refined using GLAST data

Applicable Documents

- "GLAST Large Area Telescope Flight Investigation: An Astro-Particle Physics Partnership Exploring the High-Energy Universe," P. Michelson, PI.
- GLAST DPWG (Data Products Working Group) Report, Draft 2/15/02, S. Digel http://glast.gsfc.nasa.gov/ssc/Report_DPWG.pdf
- LAT IOC (Instrument Operations Center) System Specification
- GLAST Level I Requirements Document
- Operations Concept Document, 433-OPS-0001
- Science Requirements Document, 433-SRD-000
- Project Data Management Plan (PDMP), 433-PLN-0009
- LAT Science Analysis Software Requirements Document, LAT-SS-20.0
- LAT Science Analysis Software Management Plan, LAT-MD-360.1
- LAT Event Summary Database Requirements Document Event Database Requirements Draft
- Science Analysis Tools Description Draft
- "GLAST Science Data ICD".

4 Requirements

These requirements relate to the databases used by the GLAST science analysis tools. There are a total of 7 databases identified as D1-D7 by the Science Tools Working Group (Science Analysis Environments Requirements). The first of these, D1ev and D1ph, are the LAT Level 1 event summary databases and are covered in a separate document (LAT Event Summary Database Requirements Document). D6 is a placeholder for astronomical catalogs external to the GLAST project, and D3 is the Calibration database (CALDB) designed and maintained by the HEASARC. We will design and implement the structure of the information inside D3, but the database management system will be maintained by the HEASARC. As such, D3 and D6 are outside the scope of this document as we only consider requirements on the databases themselves here. D7 is the pixellated interstellar emission model stored in a FITS file. The D7 database will then just contain version information for this file. Due to its relatively trivial nature, D7 will not be considered here either.

The three databases covered by this document are: D2 – the pointing, livetime, and mode history database, D5 – the LAT point source catalog, and D4 the pulsar ephemerides compilation.

The requirements in the next few sections cover the databases themselves. We avoid specifying implementation details and concentrate on just what the database has to do.

The first subsection will introduce the databases. The next section will discuss all the general requirements (with the exception of access related requirements) on the databases. The third section focuses on the access requirements. The final section in the document covers requirements specific to individual databases. The appendix lists the expected contents and data sizes for the databases for informational purposes.

4.1 Introduction

The databases covered here are D2, D4, and D5 as defined by the SLWG. D2 holds information regarding the spacecraft pointing history, the LAT detector livetime, and the instrument modes selected over the lifetime of the mission. D5 is a catalog of point sources identified by the LAT team as being important for gamma ray science. The final catalog is D4 a compendium of pulsar characteristics that are relevant for gamma ray analyses.

In the next two subsections are general requirements that must be met by all three databases. The common elements among them are the main drivers in this requirements document. These are relatively simple databases, so the requirements are not too stringent. It is hoped that a single type of database management system can be used for all databases, which would minimize maintenance complexity for the project.

It is expected that a DataBase Management System (DBMS) will be used to maintain the integrity of the data through ingest and retrieval. However we do not preclude the possibility of using some system based on flat files (e.g., a Berkeley database system or a custom made management tool) if all the requirements can be met.

4.2 General Requirements

4.2.1 Searchability

Must be able to search on times, integers, and reals.

4.2.2 Database handling capacity

Must be able to store and search the entire 10 years worth of mission data, information, or results.

4.2.3 Operating Systems

The database system must be able to run on hardware and operating systems commonly available in the LAT IOC, the GSSC, and the HEASARC (e.g., Linux).

4.2.4 Maintenance

Must be relatively easy to maintain. Less than 0.2 FTE per database system summed over the three databases here.

4.2.5 Assumption by the HEASARC

The databases shall be maintained by (at least) the HEASARC after the GLAST mission ends

4.2.6 Database system independence

The database system must not require the use of special proprietary features to meet the requirements in this document, as this could make changing to a different database

system later a problem. For example, the database should not need a special dialect of SQL (see § 4.2.9.1).

4.2.7 Update and backup search concurrency

Must be able to update and backup the database concurrent with searching.

4.2.8 Database Backup

The database must have tools available for incremental and full backup of the data contents.

4.2.9 DBMS specific requirements

The following requirement applies if a DBMS system is preferred over some other way to archive the data.

4.2.9.1 SQL version

If a DBMS, must use an SQL dialect close to ANSI standard SQL (currently SQL99) to be compatible with §4.2.6

4.3 Access Requirements

4.3.1 Accessibility

Must be accessible through an API in a standard GLAST programming language (e.g., Perl, C++, and Java).

4.3.2 Administrator account

There must be at least one way to restrict write privilege and configuration control to an administrator account.

4.3.3 Remote access

The database must be remotely accessible for queries and data retrieval.

4.3.4 Read Only Web queries

Must be able to restrict some remote database connections to be read only queries.

4.4 Database Specific Requirements

4.4.1 D2. Pointing, livetime, and mode history

4.4.1.1 Functional Description

This is the database of pointing and observation history that is needed to calculate exposures. It contains information about the orientation, location, and operation of the LAT for regular time intervals, ~30 s. The information also includes entries whenever instrument mode changes are made. The analysis tools do not directly access the database. Instead, it receives queries from, and passes data to, the Pointing/livetime history extractor (U2 – see the SLWG description).

4.4.1.2 Inputs

Must be able to ingest spacecraft livetime history tables generated by the LIOC for roughly 5 hour periods delivered 5 times per day.

4.4.1.3 Output

The database must be able to deliver a table with all selected rows.

4.4.1.4 Queries required

The database must be able to select rows by time intervals, filtered by other fields in the row.

4.4.1.5 Performance requirements

4.4.1.5.1 Ingest Speed

Must be able to ingest a newly delivered 5-hour data table in < 1 minute.

4.4.1.5.2 Request speed

A standard search is the expected average user query.

4.4.1.5.2.1 Standard Search

The standard search for D2 is to get 1 year's worth of consecutive data, which constitutes about 40 Mb of data (TBR). This is chosen to coincide with the LAT Event standard search. (see the LAT Event Summary Database Requirements document).

4.4.1.5.2.2 Service time

Must be able to service a standard search request in < 1minute.

4.4.1.5.2.3 Number of service requests

Must be able to service > 1500 standard search requests in a day.

4.4.1.5.3 Update speed

Must be able to input a re-processed 5-hour data table in < 5 times the time it takes to ingest a brand new table. This includes time to find and delete the old entries before inserting the new values into the database.

4.4.1.5.4 Restore speed

Must be able to rebuild the database from input files in < 1 day.

4.4.2 D5. LAT point source catalog

The information in this catalog is under the control of the LAT team.

4.4.2.1 Functional Description

This is the online form of the point source catalog. It is not directly accessed by the analysis tools, but instead receives queries from, and passes data to, the Catalog Access tool U9 (see the SAE Requirements document).

4.4.2.2 Input

Must be able to ingest the latest complete source catalog updated when necessary by LIOC

4.4.2.3 Output

Must be able to output tables with all fields for selected rows.

4.4.2.4 Queries required

- Select all entries specified by 2 dimensional region of the sky filtered by selections on other fields (e.g. energy).
- Search source by name.
- Search by 2-D coordinates.

4.4.2.5 Performance requirements

4.4.2.5.1 Ingest Speed

10 Mb of LAT point source data must be able to be ingested and ready for searching in <10 minutes.

4.4.2.5.2 Request speed

A standard search is the expected average user query.

4.4.2.5.2.1 Standard Searches

There are two standard searches, one based on a known source or a general query by region.

####### 4.4.2.5.2.1.1 Named source

The data in the table for a given source is retrieved by source name or 2-dimensional coordinates.

4.4.2.5.2.1.2 Region query

A standard region search fetches all sources in an area twice (TBR) the size of a standard event point source search. This is to ensure that there are no strong sources near the edge of the search region that could affect the analysis.

4.4.2.5.2.2 Service time

Must be able to service either type of standard search in < 1 minute.

4.4.2.5.2.3 Number of service requests

Must be able to satisfy > 1500 service requests per day.

4.4.2.5.3 Update speed

Must be able to update tables of refined point source entries at < 5 times the ingest rate,

4.4.2.5.4 Restore speed

Must be able to recreate the database from the input tables in < 1 day.

4.4.3 D4. Pulsar ephemerides

4.4.3.1 Functional Description

This is the radio x-ray, and gamma-ray pulsar timing information to be maintained during the LAT mission for assigning pulsar phases to gamma rays. The user does not directly access it, but instead the Pulsar Ephemerides Extractor tool U11 (see the SLWG description document) will perform the query. If the pulsar ephemerides are implemented in a true database system, then a front-end interface tool, equivalent to the Data Extractor for the gamma-ray data, will communicate directly with the database. The database will also receive queries from, and pass data to, the Catalog Access tool (U9).

4.4.3.2 Inputs

Must be able to ingest new pulsar ephemerides on update.
Must also be able to ingest tables with varying numbers of pulsar ephemerides.

4.4.3.3 Output

Must be able to output tables with all fields for selected rows. Output may be two tables for single and binary pulsars.

4.4.3.4 Queries required

- Must be able to select by 2 dimensional region of the sky, filtered by other parameters.
- Must be able to select individual pulsar records by source name or 2-D coordinates.
- Must be able to select by pulsar period. (TBR).

4.4.3.5 Performance requirements

4.4.3.5.1 Ingest Speed

Must be able to ingest 1 Mb worth of pulsar ephemerides tables in < 1 minute.

4.4.3.5.2 Request speed

A standard search is the expected average user query.

4.4.3.5.2.1 Standard Searches

####### 4.4.3.5.2.1.1 Named source

Retrieve pulsar record from pulsar name or from 2-D coordinates.

####### 4.4.3.5.2.1.2 Region search

Retrieve records for all pulsars in a Level 1 event summary database standard search area (a 15 degree radius circle).

4.4.3.5.2.2 Service time

Must be able to perform both types of standard searches of the database in < 1 minute

4.4.3.5.2.3 Number of service requests

Must be able to service >1500 standard requests per day.

4.4.3.5.3 Update speed

Must be able to load an updated database in < 5 times the ingest speed.

4.4.3.5.4 Restore speed

Must be able to restore the database from input data files in < 1 hour.

5 Appendix: Expected Database Characteristics

Listed here are the contents and data sizes anticipated for the databases covered in this document. This information can and will be modified as the Science Tools Working Group continues to refine the detailed specification of these databases.

5.1 D2: Pointing, Livetime, and Mode History (Spacecraft) database

5.1.1 Contents

The provisional contents of the database, defined in the GLAST Science Data ICD and augmented here to include the SAA flag and positions of the sun and moon, are as follows:

	Contents	Units
1	starting time of interval (Mission Elapsed Time)	s
2	ending time of interval (Mission Elapsed Time)	s
3	position of S/C at start of interval (x,y,z inertial coordinates)	km
4	viewing direction at start (LAT +z axis), 2 angles	dimensionless
5	orientation at start (LAT +x axis), 2 angles	dimensionless
6	zenith direction at start, 2 angles	dimensionless

7	LAT operation mode	dimensionless
8	Livetime	s
9	SAA flag	dimensionless
10	S/C longitude	deg
11	S/C longitude	deg
12	S/C altitude	km
13	direction of the sun, 2 angles	Deg
14	direction of the moon, 2 angles	Deg

The positions of the sun and moon are included here solely to facilitate cuts on their positions in the generation of exposure. They are both gamma-ray sources (the sun impulsively) and both of course shadow sources they pass in front of.

5.1.2 Data Sizes

- Table to ingest ~ 60kb
- 1 year data size ~ 100 Mb
- 10 year data size ~1000 Mb
- Number of rows in 1 year ~ 1 M rows (30s resolution)

5.2 D5: LAT point Source Catalog

5.2.1 Contents

The provisional contents of the database, defined in the GLAST Science Data ICD, are as follows:

	Contents	Units
1	source name (“telephone number”)	dimensionless
2	RA	Deg
3	Dec	Deg
4	th68 semimajor, semiminor axis, and position angle	Deg
5	th95 semimajor, semiminor axis, and position angle	Deg
6	flux (>100 MeV, avg. for the time interval of the catalog)	$cm^{-2}\ s^{-1}$
7	flux uncertainty, 1 sigma (as above)	$cm^{-2}\ s^{-1}$
8	Photon spectral index (avg)	dimensionless
9	variability index	dimensionless
10	significance (avg)	dimensionless
11	significance (peak)	dimensionless
12	peak flux (for time interval above?)	$cm^{-2}\ s^{-1}$
13	peak flux uncertainty	$cm^{-2}\ s^{-1}$
14	time of peak flux (wrt reference date)	S

15	interval of time	S
16	flux history	cm^{-2} s^{-1}
17	flux uncertainty, 1 sigma (as above)	cm^{-2} s^{-1}
18	start times of flux history entries	S
19	end times of flux history entries	S
20	candidate counterparts	dimensionless
21	Degrees of confidence for the counterparts	dimensionless
22	flags (confusion, low latitude,…)	dimensionless

5.2.2 Data Size

- Expected catalog size ~ 10 Mb
- Data size after 1 year ~ 10 Mb
- Data size after 10 years ~ 50 Mb (TBR)

5.3 D4: Pulsar Ephemerides

5.3.1 Contents

The provisional contents of the database, defined based on the pulsar timing files used for EGRET are given below. Note that for generality and consistency with format provided by pulsar observers, times in this file should be specified in MJD rather than Mission Elapsed Time. The second table below contains the additional information required for binary pulsars, but these two tables could be combined.

Parameters for any pulsar

	Contents	Units
1	Pulsar name	dimensionless
2	Right Ascension (J2000)	deg
3	Declination (J2000)	deg
4	Start of interval of validity for timing info (MJD)	days
5	End of interval of validity (MJD)	days
6	Infinite-frequency geocentric UTC arrival time of a pulse (MJD)	days
7	Pulsar rotation frequency	Hz
8	First derivative of pulsar frequency	Hz^2
9	Second derivative of pulsar frequency	Hz^3
10	Root-mean-square radio timing residual (periods)	dimensionless

11	Source of timing information	dimensionless
12	Flag for binary pulsars	dimensionless

Orbital parameters for binary pulsars

	Contents	Units
1	Pulsar name	dimensionless
2	Orbital period	s
3	Projected semi-major axis	s (light travel time)
4	Orbital eccentricity	dimensionless
5	Barycentric time (TDB scale) of periastron (MJD)	days
6	Longitude of periastron	deg
7	First derivative of longitude of periastron	deg per Julian year
8	Time-dilation and gravitational redshift parameter	s
9	First derivative of orbital period	dimensionless
10	Source of orbital parameters	dimensionless

5.3.2 Data Sizes

- Expected catalog size ~ 1 Mb (1000 pulsars entries of 1 kb each)
- Data size after 1 year ~ 1 Mb
- Data size after 10 years ~ 5 Mb (TBR)